Heat Stress

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Objectives

- Overview of the Problem
- Heat Exchange and Heat Balance
- Biologic Effects of Heat
- Measurement and Evaluation of Heat Stress
- Control of Heat Stress

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Overview of the Problem

- The hazards of living and working in Maryland under elevated temperature conditions can range from simply being annoyed by the heat to a life threatening emergency.

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Overview of the Problem

- Over 6 million workers affected by working in hot environments
- Since 1936, the National Safety Council reports 30,000 deaths due to heat-related illness (not all occupational)
- It is estimated that approximately 250 workers die annually from heat-related illnesses

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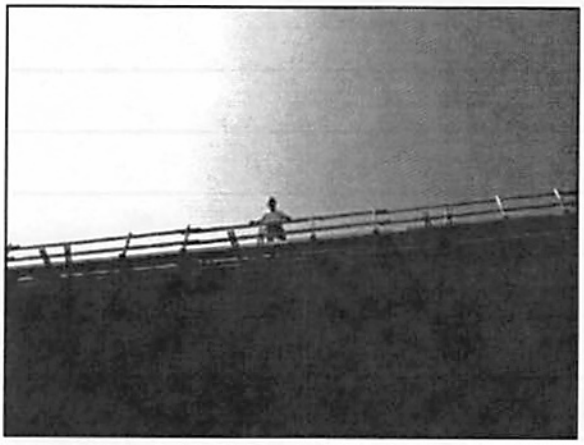

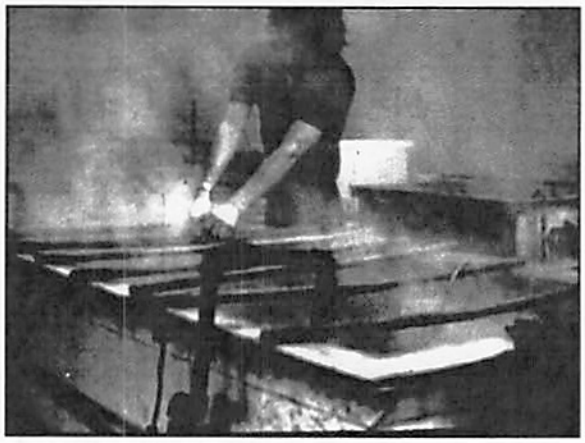

Heat Exchange and Heat Balance

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Heat Exchange and Heat Balance

- An essential for normal body function requires that the deep body core temperature be maintained within an acceptable range of about 37° C (98.6° F) ± 1° C (1.8° F)
  - Requires a constant exchange of heat between the body and environment

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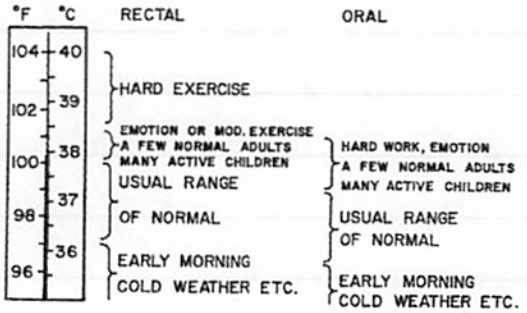

DuBois, E. F.: Fever and the Regulation of Body Temperature. Springfield, Illinois, Charles C. Thomas, 1948.
Figure 30-1. Range of Normal Rectal and Oral Temperatures [from DuBois (1)]

Heat Exchange and Heat Balance

- Basic Heat Balance Equation:

$$\Delta S = M \pm C \pm R - E$$

ΔS = change in body heat content

M = metabolism

C = convective heat exchange

R = radiant heat exchange

E = evaporative heat exchange

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Heat Exchange and Heat Balance

- Metabolism is the flow of energy and the associated physical and chemical changes taking place in the body
  - As muscle metabolism increases to meet work demands, chemical energy conversion to kinetic energy increases, which results in heat gain
  - Rate of metabolism depends on the rate and type of external work demanded

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Heat Exchange and Heat Balance

- Metabolism
  - Can be estimated by classifying work demands into categories
    - Light (up to 200 Kcal/hr)
      - Sitting or standing; light 1 hand or arm work
    - Moderate (200-350 Kcal/hr)
      - Walking about with moderate lifting or pushing
    - Heavy (350-500 Kcal)
      - Pick and shovel work

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Heat Exchange and Heat Balance

- Convective Heat Exchange
  - Convection is the exchange of heat between the skin and the surrounding air
    - Direction of heat flow depends on the temperature difference between the skin and air

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Heat Exchange and Heat Balance

- Convective Heat Exchange
  - Where the air temperature > the skin temperature, C is positive (heat flows from air to skin)
  - Where air temperature < the skin temperature, C is negative (heat flows from the body)

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Heat Exchange and Heat Balance

- Convective Heat Exchange
  - Rate of convective heat exchange depends on:
    - the magnitude of the temperature difference
    - Amount of air motion
    - Clothing

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Heat Exchange and Heat Balance

- Radiant Heat Exchange
  - Solid bodies of different temperatures have a net heat flow from the hotter to cooler surface by electromagnetic radiation
    - Primarily infrared radiation
  - Examples
    - Sun, boilers, furnaces

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Heat Exchange and Heat Balance

- Evaporative Heat Exchange
  - Sweat on the skin surface absorbs heat from the skin when evaporating into the air
  - The process of evaporation cools the skin and, in turn, the whole body

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Heat Exchange and Heat Balance

- Evaporative Heat Exchange
  - The rate of evaporative heat exchange depends on:
    - The amount of sweating
    - Air movement
    - Ambient humidity
    - Clothing

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Heat Exchange and Heat Balance

$$\Delta S = M \pm C \pm R - E$$

- Where ΔS is 0, the body is in thermal equilibrium
- Where ΔS is positive, the body gains heat
  - Body temperature increases
- Where ΔS is negative, the body loses heat
  - Body temperature decreases

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Heat Exchange and Heat Balance

- Three factors influence the degree of thermal balance
  - Climatic conditions of the environment
  - Work demands
  - Clothing

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Heat Exchange and Heat Balance

- Climatic Conditions of the Environment
  - Air temperature
  - Relative humidity
  - Air flow velocity (wind speed)
  - Intensity of infrared thermal radiation

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Heat Exchange and Heat Balance

- Work Demands
  - Metabolic rate
    - Substantial contributor to heat gain
    - 75% of energy consumed by the body ends up in the form of heat
    - Maximum metabolic rate = 1200 Kcal/hour
    - Most industrial jobs average 300-350 Kcal/hour
    - Average daily rate varies from 1700-5000 Kcal

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Heat Exchange and Heat Balance

- Clothing
  - 3 relevant characteristics
    - Insulation
    - Permeability
    - Ventilation

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Heat Exchange and Heat Balance

- Clothing Insulation
  - Measure of resistance to heat flow by radiation, convection and conduction
    - The greater the insulation, the less heat flows from warmer mass to cooler mass
    - During heat stress exposures, heat flow is reduced

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Heat Exchange and Heat Balance

- Clothing Permeability
  - Measure of water vapor movement through clothing
    - Influences the amount of evaporative cooling
  - Generally, as insulation increases, permeability decreases
  - Clothing designed as contamination barriers reduce permeability
    - Hazardous materials response scenarios

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Heat Exchange and Heat Balance

- Clothing Ventilation
  - Air movement through fabric or holes
    - Clothing designed to enable air movement affects evaporative and convective cooling
  - Affected by nature of fabric, garment construction and work demands

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Biological Effects of Heat

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Biologic Effects of Heat

- Physiologic Response to Heat
- Heat-Related Disorders

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Physiologic Response to Heat

- Central Nervous System
- Muscular Activity and Work Capacity
- Circulatory Regulation
- Sweating Mechanism
- Acclimatization
- Other Related Factors

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The Central Nervous System

- The hypothalamus acts as the primary seat of control
  - Anterior hypothalamus receives information from receptors sensitive to temperature fluctuations
  - Posterior hypothalamus provides a "set point" of core temperature and initiates physiologic responses to maintain the core temperature as it increases

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Muscular Activity and Work Capacity

- Muscles are the single largest group of tissues in the body
  - 45% of total body weight
- Heat produced by the muscles contributes to the overall heat of metabolism
  - Produce 20-25% of the body's heat production when at rest
  - Increases as muscles exert a force with motion
  - Increases deep core temperature

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Circulatory System

- Transport mechanism responsible for delivering oxygen and food stuffs to all body tissues and for transporting waste and heat from the tissues
- During exercise, or work, the autonomic nervous system initially increases blood flow to the active muscles

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Circulatory System

- When the need to dissipate heat arises, the autonomic nervous system shunts more blood to the peripheral blood vessels allowing heat to be lost
  - Sweating mechanism
  - Decreases blood volume to the central core causing increase in heart rate to maintain cardiac output
  - Circulatory volume decreases due to water loss through sweating
  - Decrease in blood pressure

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Sweat Mechanism

- Sweat glands found in the outer layers of the skin
- May sweat as much as 1 liter/hour (.3 gal/hr)
  - 8-10 liters/day (2-2.5 gal/day) is the upper limit
- Each liter of sweat evaporated represents about 580 kcal of heat to the environment
- Large losses of water, through sweating, adversely effect thermoregulation
  - High protein diets increase urination levels

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Sweat Mechanism

- Salt (sodium chloride) is an important component of sweat
  - Unacclimatized worker may lose up to 4grams/liter of sweat
  - Acclimatized workers may lose 1 gram/liter of sweat
  - Average salt intake is about 8-14 grams/day
  - Individuals on salt-restricted diets can incur a negative salt balance
    - May effect normal muscle and nerve function

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Sweat Mechanism

- Water and Electrolyte Balance
  - Imperative to replace water lost in sweat
    - Increase in water loss results in lower sweat production and increase in body temperature
  - Should drink 5-7 ounces of cool water, or low sodium non-carbonated beverage, every 15-20 minutes
    - Avoid caffeine (coffee, tea, alcohol, soda)
  - Do not rely on thirst

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Sweat Mechanism

- Rate of evaporation of sweat
  - Controlled by the difference in water vapor pressure on the sweat-wetted skin surface and air layer next to the skin and by the velocity of air movement over the skin
    - Hot, humid environments limit the amount of sweat that can be evaporated
      - Sweat drips from the skin and does not remove heat
      - Represents greater fluid and salt loss

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Acclimatization

- The physiologic changes which occur in response to a succession of days of exposure to environmental heat stress that reduce the strain caused by the heat stress of the environment

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Acclimatization

- Develops in about a 3-week period
  - Mere exposure to heat does not confer acclimatization
  - Elevated metabolic rates are required for at least 2 hours per day
  - Acclimatization to one heat stress level does not confer full acclimatization to higher level of heat stress

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Acclimatization

- Many physiologic changes are associated with:
  - Cardiovascular and peripheral vascular activities
    - Greater cardiovascular reserve
    - Better distribution of heat throughout the body
    - Reduce likelihood of lower blood pressure

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Acclimatization

- Many physiologic changes are associated with:
  - Improved body water and electrolyte maintenance
    - Increases sweating volumes by a factor of three (3) while decreasing the concentration of electrolyte loss
    - Improves precision by which sweat rates match the body's need to evaporate water and lose heat

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Acclimatization Benefits

- More finely tuned sweating reflexes with increased sweat production rate and lower electrolyte concentrations
- Lower rectal and skin temperatures than at the beginning of exposure
- More stable and better regulated blood pressure with lower pulse rates
- Improved productivity and safety

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Acclimatization

- Acclimatization can be lost quickly if the regimen of exposure is discontinued
  - Loss is transitory and can be made up
  - Loss over a weekend can be made up by Tuesday
  - Loss of 1-2 weeks with no exposure may take 4-7 days to regain
  - May be reduced where there is a lack of water for 3-5 hours

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Other Related Factors

- Age
  - Older individuals suffer more disabilities during heat stress than younger ones
    - Age itself may not be the most important criterion
    - Age-related physical conditioning and debilitations are more significant
      - Limited control of peripheral circulation
      - Illnesses that weaken cardiac output or reduce circulating blood volume

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Other Related Factors

- Obesity
  - Body fat is an especially good thermal insulator
    - Not as heavily perfused with blood as are skin and muscle
  - Fat is heavy and requires a greater expenditure of energy to move about
  - Obese people are commonly not in the best of physical condition
    - Show comparatively higher heart rates during work and exercise

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Other Related Factors

- Medications
  - Therapeutic drugs
    - Anticholinergic – may inhibit sweating
    - Sedatives – may effect thirst thresholds
    - Behavioral modification drugs – may increase body temperature
    - Appetite suppressants – may increase metabolic heat and reduce peripheral circulation

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Other Related Factors

- Drugs
  - Alcohol
    - Interferes with central and peripheral nervous function
      - Acts as a depressant
    - Associated with hypohydration
      - Peripheral vasodilation and diuresis
    - Commonly associated with heatstroke

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Other Related Factors

- Recreational Drugs
  - Physiological and perceptual disorders
  - Amphetamines
    - Increase body heat
    - Increase intravascular coagulation sometimes leading to renal damage

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Other Related Factors

- General Health
  - Cardiovascular diseases, diabetes, malnutrition all effect response to heat stress
- Individual Variations
  - Not only from individual to individual, but also within the same individual on different occasions

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Heat-Related Disorders

- Physical manifestations of untoward outcomes of heat stress exposures
- Vary in degree of severity
  - All but heatstroke resolve readily and have no lasting side effects
  - Accidents, and injuries due to accidents, increase with increasing levels of heat stress
- Are not necessarily progressive

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Heat Syncope

- Diminished levels of consciousness and possibly fainting
- Problem with cardiovascular regulation of systemic arterial blood pressure
  - Dramatic fall in blood pressure
- Occurs more in unacclimatized individuals
  - Usually occurs when weather first turns hot
- Remove to cool area, rest in recumbent position

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Heat Cramps

- Not uncommon in individuals who work hard in heat
- Cramps occur in muscles principally used in work
- Attributable to loss of electrolytes such as Na^{+}, Mg^{++}, Ca^{++} and K^{+} in sweat accompanied by copious intake of water without replacing electrolytes
- Alleviate with rest, ingestion of water and replacement of electrolytes

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Heat Rashes

- Miliaria Rubra (prickly heat)
  - Persistently sweat-wetted skin, usually in the area of restrictive clothing, appears as red papules
- Miliaria Crystallina
  - Large, watery vesicles appear on previously damage skin (sunburn) as sweat is not permitted to escape
- Miliaria Profunda
  - Blockage of sweat ducts below the skin level produces discrete and pale elevations of the skin

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Heat Exhaustion

- Mild form of heat disorder more likely to occur with greater levels of dehydration
  - As dehydration increases, the impairment of the cardiovascular system has more immediate effects
- Symptoms include loss of work capacity, diminished psychomotor skills, lightheadedness, nausea, fatigue, headache, vertigo, weakness, giddiness, cool clammy skin
- Remove from heat, rehydrate, rest
  - May require IV fluids in severe cases

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Heat Stroke

- Develops when thermoregulation has been overwhelmed, and the body has lost its major defenses to combat hyperthermia
- Characterized by elevated body temperature (greater than 105° F), and hot, dry, red skin; delirium, semiconscious or unconscious, dizzy, confused, disoriented, rapid breathing, weak and rapid pulse, seizures, coma

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Heat Stroke

- Without exception, heat stroke is a <u>medical emergency</u>
  - Remove from the heat stress area
  - Loosen clothing
  - Flood body or immerse in tepid water, and fan vigorously until medical help arrives
  - Survival/recovery depends on the immediacy of first aid and body cooling

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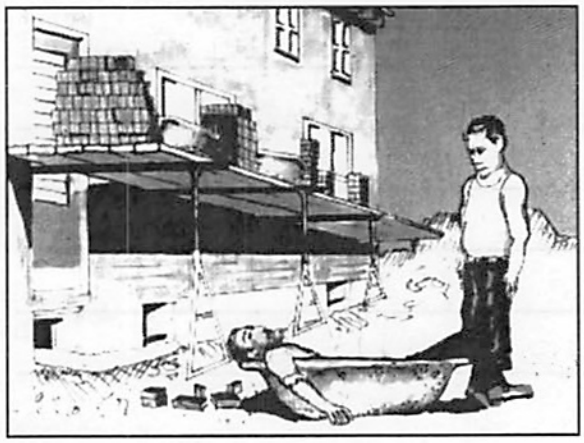

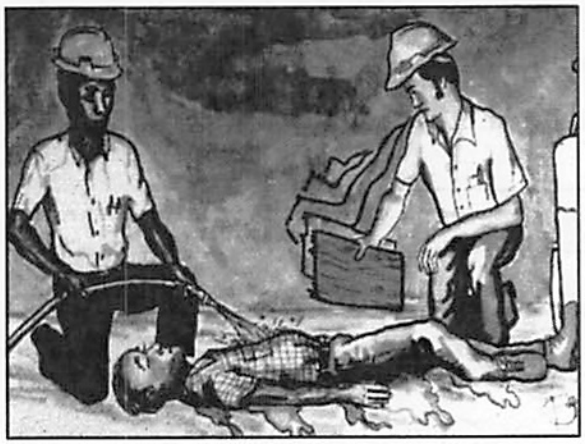

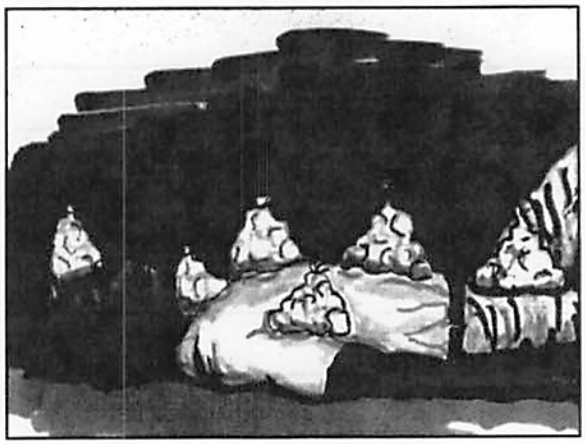

Heat Stroke

- Long-term effects of heat stroke
  - Precipitates life-threatening failure in many organs and tissues
    - May appear hours to days after body temperature has returned to normal
    - No body organ is immune
  - Renal failure is common in 30% of recovering victims

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Heat Stroke

- Long term effects of heat stroke
  - Liver damage is common
  - Brain, spinal cord and peripheral nerve damage is common
    - May effect walking, balance, posture, personality

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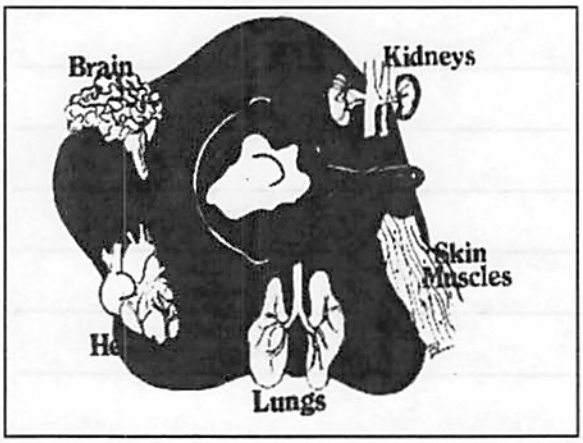

Other Biologic Effects

- Prolonged increases in deep body temperatures and chronic exposures to high levels of heat stress are also associated with
  - Temporary infertility (male and female)
  - Elevated heart rate
  - Sleep disturbance
  - Fatigue
  - Irritability
- Sustained core temperatures exceeding 102.2^0 F may endanger fetus during 1st trimester

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Measurement of Heat Stress

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Measurement of Heat Stress

- Heat stress is the aggregate of environmental and physical factors that constitute the total heat load imposed on the body
  - Physical factors
    - Metabolic heat
    - Clothing
  - Environmental factors
    - Air temperature and air movement
    - Water vapor pressure (humidity)
    - Radiant heat

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Physical Factors

- Assessment of Metabolic Heat
  - Basal metabolism
  - Work driven metabolic rate
    - Muscle metabolism
    - Force with motion (dynamic work)
    - Light, moderate, heavy
  - Break job down into components
    - Estimate metabolic rate for each component

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Estimates of Metabolic Rates

Resting	**Sitting quietly; sitting with moderate arm movement**
Light	**Sitting with moderate arm and leg movement ; standing with light work at machine or bench while using mostly arms; using a table saw; standing with light or moderate work at machine or bench and some walking about**

Estimates of Metabolic Rates

Moderate	Scrubbing in a standing position; walking about with moderate lifting or pushing; walking on level at 6 km/hr while carrying a 3 kg weight load
Heavy	Carpenter sawing by hand; Shoveling dry sand; heavy assembly work on a non-continuous basis; intermittent heavy lifting with pushing or pulling (e.g., pick & shovel work)
Very Heavy	Shoveling wet sand

TABLE 3. Assessment of Work Load

Average values of metabolic rate during different activities.

A. Body position and movement	kcal/min
Sitting	0.3
Standing	0.6
Walking	2.0–3.0
Walking up hill	add 0.8 per meter (yard) rise

B. Type of Work		Average kcal/min	Range kcal/min
Hand work	*light*	0.4	0.2–1.2
	heavy	0.9	
Work with one arm	*light*	1.0	0.7–2.5
	heavy	1.7	
Work with both arms	*light*	1.5	1.0–3.5
	heavy	2.5	
Work with body	*light*	3.5	2.5–15.0
	moderate	5.0	
	heavy	7.0	
	very heavy	9.0	

TABLE 4. Activity Examples

- Light hand work: writing, hand knitting
- Heavy hand work: typewriting
- Heavy work with one arm: hammering in nails (shoemaker, upholsterer)
- Light work with two arms: filing metal, planing wood, raking of a garden
- Moderate work with the body: cleaning a floor, beating a carpet
- Heavy work with the body: railroad track laying, digging, barking trees

Sample Calculation

Assembly line work using a heavy hand tool.

A.	Walking along	2.0 kcal/min
B.	Intermediate value between heavy work with two arms and light work with the body	3.0 kcal/min
	Subtotal:	5.0 kcal/min
C.	Add for basal metabolism	1.0 kcal/min
	Total:	6.0 kcal/min

Environmental Factors

- Dry bulb temperature
- Psychrometric wet bulb temperature
- Ambient water vapor pressure
- Natural wet bulb temperature
- Air speed
- Globe temperature

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Environmental Factors

- Wet Bulb Globe Temperature (WBGT)
  - Incorporates
    - Dry bulb temperature = db
      - Direct measure of air temperature
    - Natural wet bulb temperature = nwb
      - Sensitive to both humidity and air movement
    - Globe temperature = g
      - Measures radiant heat
  - Used to measure industrial heat stress

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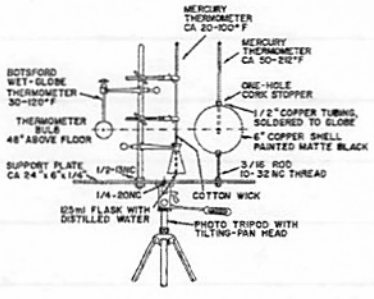
MERCURY THERMOMETER CA 20-100° F
MERCURY THERMOMETER CA 50-212° F
BOTSFORD WET-GLOBE THERMOMETER 30-120° F
ONE-HOLE CORK STOPPER
THERMOMETER BULB 48" ABOVE FLOOR
1/2" COPPER TUBING, SOLDERED TO GLOBE
6" COPPER SHELL PAINTED MATTE BLACK
SUPPORT PLATE CA 24" x 6" x 1/4"
1/2-13NC
3/16 ROD 10-32 NC THREAD
1/4-20NC
COTTON WICK
125ml FLASK WITH DISTILLED WATER
PHOTO TRIPOD WITH TILTING-PAN HEAD

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Calculating WBGT

- Indoors, or outdoors with shade or clouds:

$$WBGT_{in} = 0.7T_{nwb} + 0.3T_g$$

- Outdoors, under direct sunlight:

$$WBGT_{out} = 0.7T_{nwb} + 0.2T_g + 0.1T_{db}$$

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Evaluation of Heat Stress

- There are no MOSH or OSHA standards for heat stress conditions
- Historically, MOSH and OSHA have used recommended industry values for evaluating heat stress conditions
  - National Institute for Occupational Safety and Health (NIOSH)
  - American Conference of Governmental Industrial Hygienists (ACGIH)

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NIOSH Heat Stress Values

- Developed recommended Heat Stress standard in 1972
  - Recommendations for An Occupational Standard for Workers Exposed to Hot Environments
    - Updated in 1986
    - Available at www.cdc.niosh/72-10269.html

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NIOSH Heat Stress Values

- Recommended standard attempts to reduce "sentinel health events"
  - Workplace limits and surveillance
  - Medical surveillance
  - Surveillance of sentinel events
  - Posting of hazardous areas
  - Protective clothing and equipment
  - Control of heat stress
  - Recordkeeping

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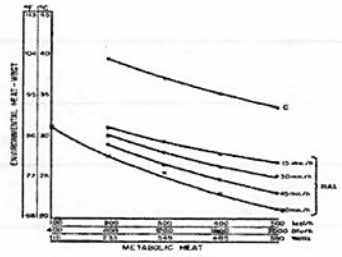
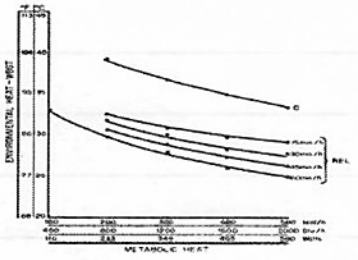


Figure 1. Recommended Heat-Stress Alert Limits
Heat-Unacclimatized Workers

C = Ceiling Limit
REL = Recommended Alert Limit
*For "standard worker" of 70 kg (154 lbs) body weight and 1.8 m² (19.4 ft²) body surface.
Based on References 2,3,4,5,6,7,8.



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Heat-Acclimatized Workers

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Based on References 2,3,4,5,6,7,8.

TABLE V-3.--Estimating energy cost of work by task analysis

A. Body position and movement	kcal/min*
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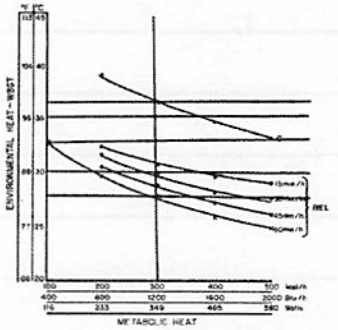
Walking uphill	add 0.8 per meter rise

B. Type of work	Average kcal/min	Range kcal/min
Hand work		
light	0.4	0.2-1.2
heavy	0.9	
Work one arm		
light	1.0	0.7-2.5
heavy	1.8	
Work both arms		
light	1.5	1.0-3.5
heavy	2.5	
Work whole body		
light	3.5	2.5-9.0
moderate	5.0	
heavy	7.0	
very heavy	9.0	
C. Basal metabolism	1.0	

D. Sample calculation**	Average kcal/min
Assembling work with heavy hand tools	
1. Standing	0.6
2. Two-arm work	3.5
3. Basal metabolism	1.0
Total	5.1 kcal/min

* For standard worker of 70 kg body weight (154 lbs.) and 1.8 m² body surface (19.4 ft²).
**Example of measuring metabolic heat production of a worker when performing initial screening.
Adapted from References 2,100,111,112.



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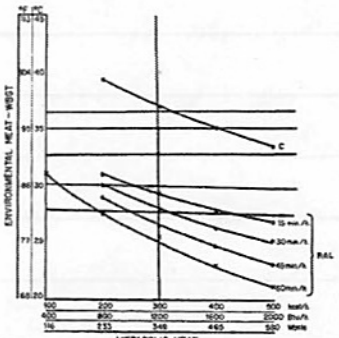

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Heat-Unacclimatized Workers

ACGIH Heat Stress Evaluation

- ACGIH Threshold Limit Value (TLV) changed in 2000
- Uses evaluation scheme, WBGT readings, clothing and metabolic rates to screen potentially unsafe heat stress conditions
  - Detailed analyses may be needed in some cases

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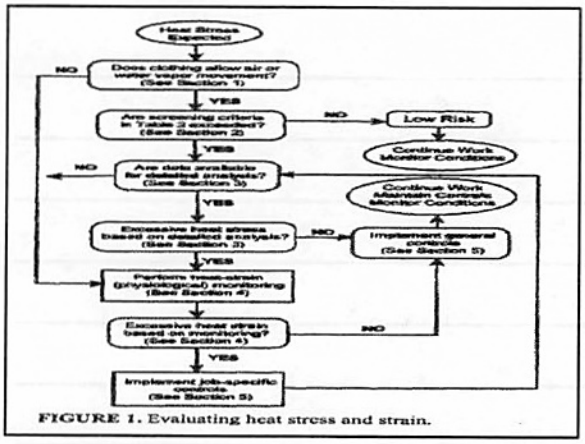
Heat Stress Exposure
NO
Does clothing allow air or water vapor movement? (See Section 1)
YES
Are screening criteria in Table 2 exceeded? (See Section 2)
NO
Low Risk
Continue Work Monitor Conditions
YES
NO
Are data available for detailed analysis? (See Section 3)
Continue Work Maintain Controls Monitor Conditions
YES
Excessive heat stress based on detailed analysis? (See Section 3)
NO
Implement general controls (See Section 5)
YES
Perform heat-strain (physiological) monitoring (See Section 4)
Excessive heat strain based on monitoring? (See Section 4)
NO
YES
Implement job-specific controls (See Section 5)

FIGURE 1. Evaluating heat stress and strain.

TABLE 1. Additions to Measured WBGT Values (°C) for Some Clothing Ensembles

Clothing Type	WBGT Addition*
Summer work uniform	0
Cloth (woven material) coveralls	+3.5
Double cloth coveralls	5

*These values must not be used for encapsulating suits or garments that are impermeable or highly resistant to water vapor or air movement through the fabrics.

TABLE 2. Screening Criteria for Heat Stress Exposure (WBGT values in °C)

	Acclimatized				Unacclimatized			
Work Demands	Light	Moderate	Heavy	Very Heavy	Light	Moderate	Heavy	Very Heavy
100% Work	29.5	27.5	26		27.5	25	22.5	
75% Work; 25% Rest	30.5	28.5	27.5		29	26.5	24.5	
50% Work; 50% Rest	31.5	29.5	28.5	27.5	30	28	26.5	25
25% Work; 75% Rest	32.5	31	30	29.5	31	29	28	26.5

Notes:

- See Table 3 and the Documentation for work demand categories.
- WBGT values are expressed in °C, and represent thresholds near the upper limit of the metabolic rate category.
- If work and rest environments are different, hourly time-weighted averages (TWA) should be calculated and used. TWAs for work rates should also be used when the work demands vary within the hour.
- Values in the table are applied by reference to the "Work-Rest Regimen" section of the Documentation and assume 8-hour workdays in a 5-day workweek with conventional breaks as discussed in the Documentation. When workdays are extended, consult the "Application of the TLV" section of the Documentation.
- Because of the physiological strain associated with Very Heavy work among less fit workers regardless of WBGT, criteria values are not provided for continuous work and for up to 25% rest in an hour. The screening criteria are not recommended, and a detailed analysis and/or physiological monitoring should be used.

Estimates of Metabolic Rates

(Table 3, ACGIH TLV)

Resting	Sitting quietly; sitting with moderate arm movement
Light	Sitting with moderate arm and leg movement ; standing with light work at machine or bench while using mostly arms; using a table saw; standing with light or moderate work at machine or bench and some walking about

Estimates of Metabolic Rates

(Table 3, ACGIH)

Moderate	Scrubbing in a standing position; walking about with moderate lifting or pushing; walking on level at 6 km/hr while carrying a 3 kg weight load
Heavy	Carpenter sawing by hand; Shoveling dry sand; heavy assembly work on a non-continuous basis; intermittent heavy lifting with pushing or pulling (e.g., pick & shovel work)
Very Heavy	Shoveling wet sand

ACGIH Heat Stress Evaluation

- ACGIH recognizes that human responses to heat stress vary greatly, not only from person to person in the same environment, but also for the same person in different exposures and from time to time.

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ACGIH Heat Stress Evaluation

- Where WBGT readings exceed Table 2 of the ACGIH TLV, it is possible that they do not represent an unacceptable condition.
  - To make this determination a detailed analysis is required

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ACGIH Heat Stress Evaluation

- Detailed Analysis
  - Must have adequate information on heat stress effects of required clothing
  - First conduct a task analysis that includes a time weighted average of the WBGT and metabolic rate; and
  - Second, follow rational model of heat stress, such as the ISO required sweatrate or Heat Stress Index

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ACGIH Heat Stress Evaluation

- Where information does not exist for a detailed analysis (or exceeds it), physiological monitoring is performed to assess degree of heat strain
  - See Table 4 of the ACGIH TLV, Guidelines for Limiting Heat Strain
    - An individual's exposure to heat stress should be discontinued if any of the conditions appear

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ACGIH Heat Stress Evaluation

- Evaluating Heat Strain
  - Recognize personal characteristics that predispose individuals to heat strain
    - Acclimatization, age, gender, body fat, general health, medications/drugs
  - Watch for the presentation of early signs and symptoms of heat stress and remediate them as soon as they appear

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ACGIH Heat Stress Evaluation

- Early warning signs and symptoms of heat strain
  - Increased heart rate and blood flow to the skin may cause deceased blood pressure and blood flow to the brain
    - Dizziness, nausea, irritability, lightheadedness, blurred vision, shaking of hands, clumsiness, vague flu-like symptoms, postural instability
  - Profuse sweating

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Control of Heat Stress

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Control of Heat Stress

- General Controls
  - Appropriate when heat stress levels exceed recommended values, or when the clothing dictates a more detailed analysis or physiological monitoring
- Job-Specific Controls
  - Required when heat stress conditions exceed the thresholds of a detailed analysis or when physiological monitoring dictates controls

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General Heat Stress Controls

- Training
  - Description of heat stress
    - Environment, work demands, clothing
    - Physiological responses including acclimatization
  - Recognition of, and first aid for, heat-related disorders
    - Description of heat-related disorders, including their symptoms and causes
    - Description of first aid measures for each disorder

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General Heat Stress Controls

- Training
  - Heat stress hygiene practices
    - Fluid replacement
    - Self-determination
    - Diet
    - Life-style
    - Health status
    - Acclimatization

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General Heat Stress Controls

- Medical Surveillance
  - Pre-placement and periodic medical exams are recommended for persons routinely exposed to significant levels of heat stress
    - Consult with a medical authority to establish inclusion criteria
  - Medical review of sentinel health events
    - Serious heat-related disorders or repeated complaints

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General Heat Stress Controls

- Heat-Alert Programs
  - Review training materials for new season
  - Prepare work place for heat stress conditions and check operability of controls
  - Prepare for changes in staffing and work practices
  - Review policies and procedures
  - Establish Heat-Alert State and implementation

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Job-Specific Heat Stress Controls

- Engineering Controls
  - Reduce physical work demands
  - Reduce air temperatures
    - Air conditioning, dilution ventilation
  - Reduce humidity
  - Change clothing

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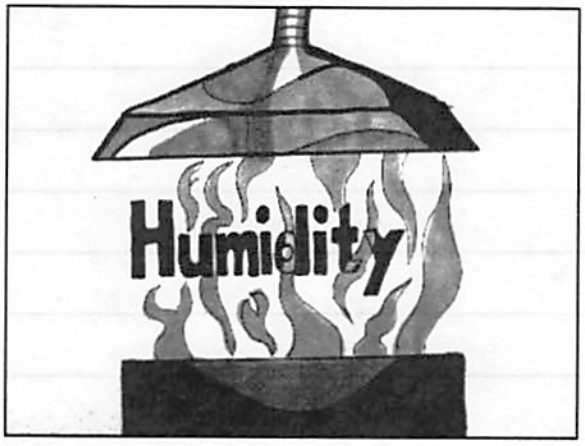

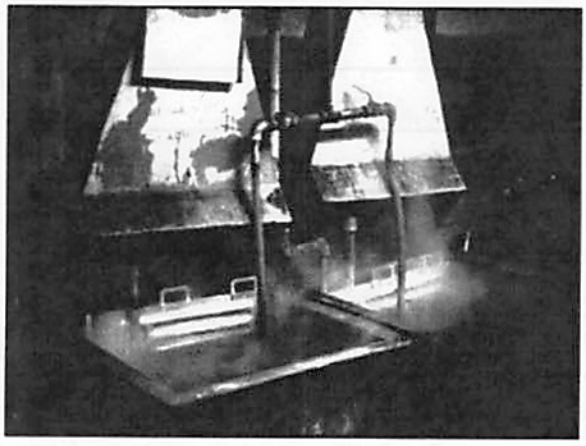

Job-Specific Heat Stress Controls

- Engineering Controls
  - Reduce radiant heat
    - Shielding, insulation
  - Increase air movement
    - Enhances evaporative cooling if <95 ^{0} F
    - Temperature ranges of 95^0 – 104^0 F increase convective heat gain which may be offset by additional air movement
    - Temperatures above 104^0 F exacerbates heat gain
    - May effect air contaminant control

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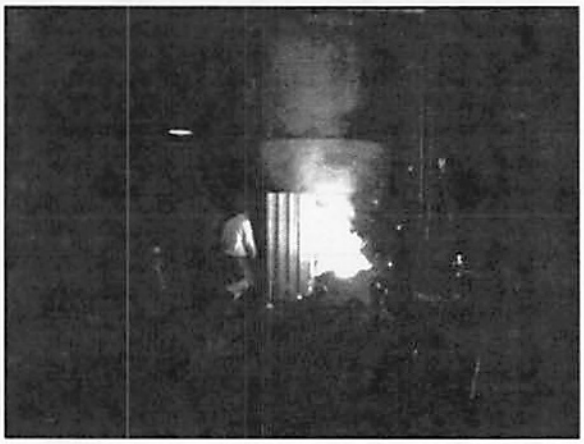

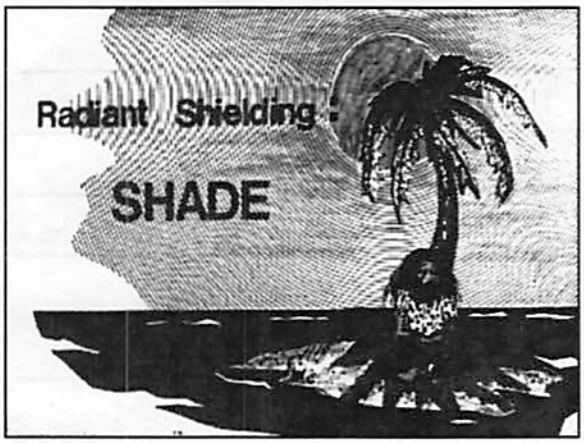

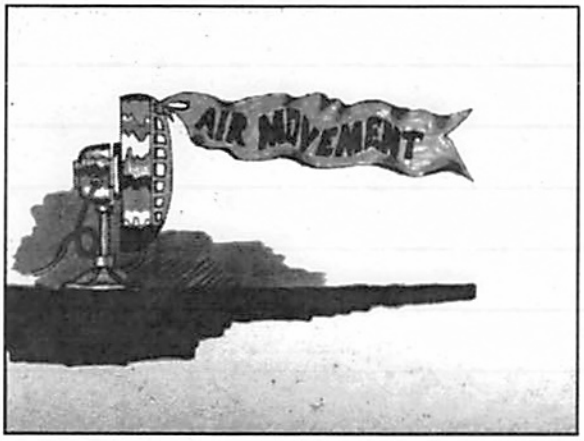

Job-Specific Heat Stress Controls

- Administrative and Work Practice Controls
  - Acclimatization
    - Newly exposed or re-exposed after absence
  - Pacing of work
    - Reduce metabolic rate over a longer period of time

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Job-Specific Heat Stress Controls

- Administrative and Work Practice Controls
  - Sharing work
  - Scheduling of work
  - Self-determination
  - Personal monitoring

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Job-Specific Heat Stress Controls

- Administrative and Work Practice Controls
  - Imperative to replace water lost in sweat
  - Should drink 5-7 ounces of cool water, or low sodium non-carbonated beverage, every 15-20 minutes
    - Avoid caffeine (coffee, tea, alcohol, soda)
  - Do not rely on thirst

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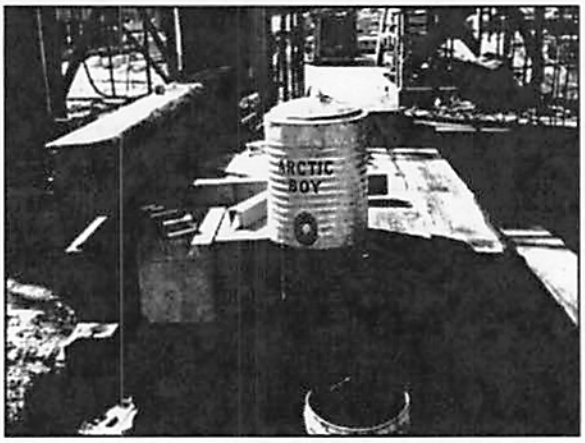

Job-Specific Heat Stress Controls

- Personal Protective Equipment (PPE)
  - Circulating air systems
    - Air-line or portable blower systems
    - Can reduce temperature by about 18^0 F
    - Need Grade D breathing air
  - Circulating water systems
  - Ice garments
  - Reflective clothing

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Another Free Service From MOSH

On-Site Consultation

MOSH On-Site Consultation

- For small private sector employers
  - No more than 250 employees at the worksite and
  - Not part of a corporation with more than 500 employees nationwide
- Services are also available for public sector employers

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MOSH On-Site Consultation

- Confidential -- not part of MOSH enforcement
- Participants are shielded from programmed MOSH enforcement inspections while consultation is in progress
- Recognition and exemption program (SHARP) for small fixed-site employers who develop an exemplary safety and health management system
- SHARP employers are exempted from programmed MOSH inspections
- Exemptions are renewable annually

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Typical On-Site Consultation Services

- Identifying conditions that might result in injury, illness or MOSH citations
- Assessing existing safety and health management systems and making recommendations for improvement
- Providing advice on hazard correction
- Advising on the safe use of chemicals

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Typical On-Site Consultation Services

- Providing guidance in the development of programs such as respiratory protection, lockout/tagout, hazard communication, bloodborne pathogens, and ergonomics
- Testing air contaminant concentrations and measuring noise levels
- Providing safety and health training to management and staff

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Need More Information?

- Call MOSH Consultation Services to discuss your specific needs
  – 410-527-4472
- Remember -- services are free!

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How Does Your Company Contact MOSH?

General Information	(410) 527-4499
Report fatality/catastrophes	(888) 257-MOSH
Training & Education	(410) 527-2091
Consultation	(410) 527-4472
Region 1 (Easton)	(410) 819-5860
Region 2 (Industrial Hygiene)	(410) 527-4499
Region 3 (Central)	(410) 527-4426
Region 4 (Hagerstown)	(301) 791-4699

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